A11102 163016

NAT'L INST OF STANDARDS & TECH R.I.C.

A11102163016

/Technologic papers of the Bureau of Sta
T1 .U4 V23-32;1911-1913 C.1 NBS-PUB-C 19

DEPARTMENT OF COMMERCE

TECHNOLOGIC PAPERS

OF THE

BUREAU OF STANDARDS

S. W. STRATTON, DIRECTOR

No. 29

VARIATIONS IN RESULTS OF SIEVING WITH STANDARD CEMENT SIEVES

BY

RUDOLPH J. WIG

and

J. C. PEARSON

[AUGUST 1, 1913]

WASHINGTON
GOVERNMENT PRINTING OFFICE
1913

PUBLICATIONS ISSUED BY THE BUREAU OF STANDARDS, DEPARTMENT OF COMMERCE

TECHNOLOGIC PAPERS

1911

1. The Effect of Preliminary Heat Treatment upon the Drying of Clays (53 pp.) ... *A. V. Bleininger*
2. The Strength of Reenforced Concrete Beams. Results of Tests of 333 Beams (first series) (200 pp.) ... *R. L. Humphrey and L. H. Losse*
3. Tests of Absorbtive and Permeable Properties of Portland Cement Mortars and Concretes, Together with Tests of Damp Proofing and Waterproofing Compounds and Materials (127 pp.) ... *Rudolph J. Wig*
4. The Effect of Added Fatty and Other Oils upon the Carbonization of Mineral Lubricating Oils (14 pp.) ... *C. E. Water*
5. The Effect of High-Pressure Steam on the Crushing Strength of Portland Cement Mortar and Concrete (25 pp.) ... *R. J. Wig*
6. The Determination of Chromium and its Separation from Vanadium, In Steels (6 pp.) ... *J. R. Cain*
7. The Testing of Clay Refractories, With Special Reference to Their Load Carrying Capacity at Furnace Temperatures (78 pp.) ... *A. V. Bleininger and G. H. Brown*
8. A Rapid Method for the Determination of Vanadium in Steels, Ores, etc., Based on Its Quantitative Inclusion by the Phosphomolybdate Precipitate (20 pp.) ... *J. R. Cain and J. C. Hostetter*

1912

9. The Density and Thermal Expansion of Linseed Oil and Turpentine (27 pp.) ... *H. W. Bearce*
10. The Melting Points of Fire Bricks ... *C. W. Kanolt*
11. Comparison of Five Methods Used to Measure Hardness (27 pp.) .. *Ralph P. Devries*
12. Action of the Salts in Alkali Water and Sea Water on Cements (157 pp.) ... *P. H. Bates, A. J. Philips, and Rudolph J. Wig*

1913

13. The Evaporation Test for Mineral Lubricating and Transformer Oils (13 pp.) ... *C. E. Waters*
14. Legal Specifications for Illuminating Gas (31 pp.) .. *E. B. Rosa and R. S. McBride*
15. Surface Insulation of Pipes ... *Burton McCollum and O. S. Peters*
16. The Manufacture of Lime (130 pp.) ... *W. E. Emley*
17. The Function of Time in the Vitrification of Clays (26 pp) ... *G. H. Brown and G. A. Murray*
18. Electrolysis in Concrete (137 pp.) .. *E. B. Rosa, Burton McCollum, and O. S. Peters*
19. Physical Testing of Cotton Yarns (31 pp.) ... *W. S. Lewis*
20. Determination of Sulphur in Illuminating Gas (46 pp.) ... *R. S. McBride and E. R. Weaver*
21. The Dehydration of Clays (23 pp.) ... *G. H. Brown and E. T. Montgomery*
22. The Effect of Overfiring Upon the Structure of Clays (23 pp.) ... *A. V. Bleininger and E. T. Montgomery*
23. The Technical Control of the Colloidal Matter of Clays (118 pp.) ... *H. E. Ashley*
24. The Determination of Phosphorus in Steels Containing Vanadium (11 pp.) ... *J. R. Cain and F. H. Tucker*
25. Electrolytic Corrosion of Iron in Soils (69 pp.) .. *Burton McCollum and K. H. Logan*
26. Earth Resistance and Its Relation to Electrolysis ... *Burton McCollum and K. H. Logan*
27. Electrolysis Due to Railway Currents ... *E. B. Rosa and Burton McCollum*
28. Methods of Making Electrolysis Surveys ... *Burton McCollum and G. H. Ahlborn*
29. The Variation in Results of Sieving with Standard Cement Sieves (16 pp.) ... *R. J. Wig and J. C. Pearson*

DEPARTMENT OF COMMERCE

TECHNOLOGIC PAPERS

OF THE

BUREAU OF STANDARDS

S. W. STRATTON, DIRECTOR

No. 29

VARIATIONS IN RESULTS OF SIEVING WITH STANDARD CEMENT SIEVES

BY

RUDOLPH J. WIG
and
J. C. PEARSON

[AUGUST 1, 1913]

WASHINGTON
GOVERNMENT PRINTING OFFICE
1913

VARIATIONS IN RESULTS OF SIEVING WITH STANDARD CEMENT SIEVES

By Rudolph J. Wig and J. C. Pearson

CONTENTS

I. INTRODUCTION

Since the development of the Bureau's specification for standard cement sieves[1] inquiries have been received as to the limits of accuracy of sieves measured and sealed by the Bureau as standard sieves, when they are used in the laboratory in determining the degree of fineness of a sample of cement or other material.

As the degree of fineness is usually made a part of the specification and contract upon which the cement is purchased and the material may be rejected if the fineness falls below a certain requirement, the accuracy of the fineness determination is often in dispute, and there is no available information as to the tolerance which should be placed upon such determinations.

The testing of sieves and sieve cloth by the Bureau during the past two years has shown that the tolerance of the present specification for diameter of wire and spacing can not be much reduced without making the cost of such selected cloth prohibitive.

A number of tests have recently been carried out at the Bureau of Standards to see what order of discrepancy may be expected in fineness determinations of cement when made by the standard routine method of sieving.

10646°—13

[1] Circular No. 39, Bureau of Standards.

II. SCOPE OF TESTS

Discrepancies in determinations of fineness may be attributed to: (*a*) Differences in the standard sieves; (*b*) the "personal equation" of the observer; (*c*) lack of uniformity in the samples; (*d*) the residual differences when the three foregoing sources of error are, as far as possible, eliminated.

Considering the last mentioned first, it is evident that the experienced and careful worker, using a high-grade sieve and sieving samples of a well-dried and thoroughly mixed cement according to a fixed program, can by repeated trials determine a maximum limit of tolerance for residual differences. When this has been established, the same observer is in a position to check uniformity of samples of other cements—that is, he may check their uniformity only with an accuracy not greater than his own maximum limit of tolerance. There is at present, so far as we know, no simpler method of detecting lack of uniformity in finely ground material.

Following the results reported below, an attempt has been made to establish—

1. What variations in fineness determinations are permissible under the most favorable conditions.

2. What variations may arise from differences in the "standard" sieves themselves.

3. What error may be looked for in a single fineness determination on a standard sieve as performed by an ordinary laboratory worker of average experience.

4. Whether variations from the standard method of sieving are appreciable.

5. Whether "personal equation" is appreciable in the limited number of tests made.

6. Whether an arbitrary system of "demerits" determined from careful measurements of a sieve is a reliable indication of its sieving value.

III. TESTS

The tests were made on a lot of sieves submitted for the purpose by two well-known firms. As indicated below, four men made independent determinations of fineness on 24 of the sieves, while two men made the majority of determinations on the remaining sieves. The cement used was a good brand of normal grade Portland, which was first thoroughly dried, screened through a No. 20 sieve, and finally mixed by long-continued rolling on a large sheet of stout manila wrapping paper. The determinations were made according to the standard method of sieving described in the United States Government Specification for Portland Cement,[1] as follows:

> The determination of fineness should be made on a 50-gram sample, which may be dried at a temperature of 100° C (212° F) prior to sifting. The coarsely-screened sample (cement is ordinarily screened through a No. 20 sieve before mixing for routine tests) should be weighed and placed on the No. 200 sieve, which, with the pan and cover attached, should be held in one hand in a slightly inclined position and moved forward and backward in the plane of inclination, at the same time striking the side gently about two hundred times per minute against the palm of the other hand on the upstroke. The operation is to be continued until not more than 0.05 grams will pass through in one minute.

While the experienced worker always develops some peculiarity in his method of sifting, which contributes to or determines his "personal equation," undoubtedly the chief factor to be guarded against is carelessness. This factor may explain to some extent the rather wide variations observed, but it may be safely assumed that the sum total of carelessness on the part of those who participated in the tests is less, rather than greater, than that made in normal routine work, and it is believed that the average results represent what may be expected from experienced routine workers in similar laboratories.

[1] Circular No. 33, Bureau of Standards.

In the following tables the observers are designated by letters and the sieves by numbers:

TABLE 1

Results of Sieving Tests Made by Four Observers on 12 Standard No. 200 Sieves

Sieve	Observers					Average	Maximum variation from average
	A	B	C	D	E		
1	80.30	79.72	80.40	80.24		80.16	0.44
2	79.88	80.66	80.20	80.46		80.30	.42
3	79.78	80.44	80.44 80.44		80.51	80.32	.54
4	80.62	80.00	80.44	80.76		80.46	.46
5	80.50	80.72	80.18	80.56		80.49	.31
6	80.24	80.84	80.66	80.36		80.52	.32
7	80.40	80.57	80.44	80.80		80.55	.25
8	80.30	80.82	80.26	81.14		80.63	.51
9	80.34	80.90	80.72	81.04		80.75	.41
10	80.56	80.76	80.90	81.50		80.93	.57
11	80.42	80.40	81.36	81.60		80.94	.66
12	81.04	81.00	80.76	81.34		81.03	.31
Average	80.36	80.57	80.55	80.89		80.59	.43
Personal equation	+.23	+.02	+.04	−.29			

Table 1 shows the results obtained by four observers using the same cement on 12 standard No. 200 sieves. The figures are percentages of total cement passing the sieves.

An approximate value of the range that may be expected due to differences in the sieves may be obtained from the averages for each sieve, which are taken as the most probable sieving values. The highest is seen to be 81.03 per cent, the lowest 80.16 per cent, range 0.87 per cent. A "standard" sieve according to these results, may therefore differ from the mean value of a number of good sieves by nearly 0.5 per cent. It is to be borne in mind, however, that the mean value of a number of good sieves will generally be greater than the amount passed by an ideal No. 200 sieve, since the prescribed limits of tolerance allow greater latitude below 200 meshes than above. Thus, careful measurements of cloth on sieve No. 1 showed this to be the nearest of the

lot to the ideal No. 200 sieve, and repeated fineness determinations with this sieve showed that its most probable sieving value was about 80.30 per cent, which is 0.3 per cent less than the observed average value for all the sieves. It follows, therefore, that a "standard" sieve may have a true correction to the ideal sieve of as much as 0.7 per cent.

The last column of Table 1 shows that the error to be looked for in a single fineness determination is likely to be at least 0.5 per cent, a figure which will, of course, vary with the reliability of the observer. A search through Table 1, however, will show that all the observers have missed the average value on one or more sieves by more than 0.4 per cent.

A roughly approximate value of personal equation may be obtained by averaging all the determinations made by each observer and comparing this with the mean value of all observers. The values are given in the last line of Table 1. The number of observers is too small to establish this factor with any certainty, but for observers A and D, whose averages show appreciable deviations from the others, it may be noted that 8 times out of 12 A's value is less than the mean value for the sieves, and 8 times out of 12 D's value is greater than the mean value for the sieves.

TABLE 2

Results of Sieving Tests Made by One Observer on 1 Standard Sieve using Five Different Methods

Trial	1 (200 strokes)	2 (250 strokes)	3 (150 strokes)	4 (Single washer)	5 (6 steel balls)
1	80.30	80.06	80.44	79.76	80.36
2	80.44	80.08	80.36	79.46	79.98
3	80.16	80.02	80.24	80.08	80.18
Average	80.30	80.05	80.35	79.77	80.17

Table 2 represents the results obtained by a single observer on sieve No. 1, using five slightly varying methods of sieving, each method being given three careful trials. These methods include the deviations from the standard method of sieving which are

sometimes permitted in fineness determinations. Column 1 contains the results obtained by moving the sieve back and forth 200 times per minute, that is, according to the standard specifications. Column 2 contains the results obtained from sieving at the rate of 250 strokes per minute, this rate requiring, of course, short quick strokes. Similarly Column 3 contains the results obtained by sieving at the rate of 150 strokes per minute, the strokes being relatively long and slow. Column 4 contains the results obtained by sieving according to standard specifications, using, however, a single brass washer about ¾ inch in diameter to aid in breaking up the small lumps of fine material. Column 5 shows the effect of using six $\frac{3}{16}$-inch steel balls in place of the washer.

While the determinations are too few in number to show decided differences, the order in which the results actually occur is interesting. From the lowest to the highest amounts passing the sieve, the order is as follows:

1. Sieving with a washer on the sieve.
2. Sieving with steel balls on the sieve.
3. Sieving at 250 strokes per minute.
4. Sieving at 200 strokes per minute.
5. Sieving at 150 strokes per minute.

Thus the trials indicate that the simplest and easiest method—that is, sieving at the moderate rate of about 150 strokes per minute—gives the maximum percentage of cement passing the sieve. The somewhat erratic results obtained by the use of the washer and the balls, which might have been anticipated to give the highest values, are seen to be the lowest; and the variations are to be accounted for by the uncertainty of the stopping point. The use of washer and balls seems to increase the irregularity of the amounts obtained in successive minutes toward the end of the sieving, so that one may naturally stop somewhat earlier than he would if the amounts were decreasing regularly. It is evident, of course, that for every minute over or under sieving, the error introduced is approximately 0.1 per cent. On this basis the maximum limit of tolerance for the best work can hardly be less than 0.2 per cent, since the most careful observer may readily be one minute short or one minute over.

The fact that appreciably more cement passes the sieve at 150 strokes per minute than at 250 strokes per minute is no doubt due to the more rapid horizontal motion of the sieve in the latter case, whereby particles just under the smallest size retained have less opportunity to fall through the sieve openings than when the sieve is moving at the slower rate.

In all sieving tests it is tacitly assumed that the specifications need not be closely followed until the greater part of the fine material has already been sieved through, that is, the final result is assumed to be independent of the manner in which the first partof the sieving has been performed. This is no doubt justified in hand sieving when no washers or balls are used to hasten the process, but one may well question the assumption when vigorous methods are used, as in most routine work. In all trials reported in Table 2, the specifications were followed throughout the entire time of sieving.

It may of course be possible to form an estimate of the relative sieving value of a sieve from the direct measurements made upon it of the number and diameters of the warp and shoot wires, and the uniformity of spacing of the wires. The establishment, however, of a hard and fast demerit system for calculating the sieving value involves much guesswork, and the attempts thus far made at the Bureau of Standards to devise such a system have been only partially successful. It is not therefore worth while to go into the details of the manner in which the demerits have been assigned other than to state that consideration was given to all factors which affect the variations in size and distribution of the openings.

TABLE 3

Relation Between Value of Sieves as Actually Tested and Estimated Value Based on Sieve Measurements

Sieve	Sieve value	Demerits	Sieve	Sieve value	Demerits
1	80.16	− 408	7	80.55	− 548
2	80.30	+1312	8	80.63	−1386
3	80.32	+1304	9	80.75	− 188
4	80.46	−2363	10	80.93	−1573
5	80.49	−1101	11	80.94	−2340
6	80.52	−1150	12	81.03	−3135

Table 3 gives the average sieving values of the sieves listed in Table 1, together with their demerits arbitrarily assigned from analysis of direct cloth measurements on the sieves. For convenience in comparing the observed and calculated values, the table is arranged in order of the sieving values, and the results are

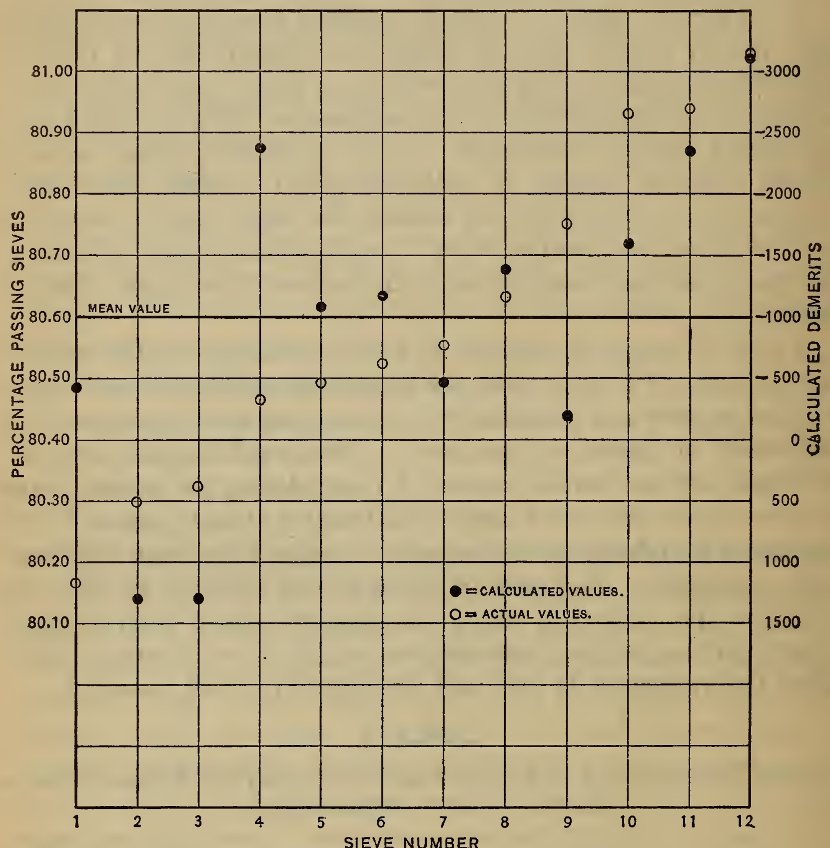

Fig. 1.—*Relation between value of sieves as actually tested and estimated value based on sieve measurements*

plotted in Fig. 1. The observed values are put in directly on the vertical lines passing through the numbers of the sieves, which are laid off at equal intervals on the horizontal axis. The calculated values are obtained in the following way:

It is seen that the total range of demerits is from —1312 to +3135, or 4447. Corresponding to this is a total range of 0.87 per cent in the observed sieving values, so that 0.01 per cent in the observed sieving value is approximately equal to 50 demerits. In the figure the total range of demerits is laid off to equal the total range of sieving values, so that all intermediate values may be definitely read off either as demerits or as calculated sieving values.

While the agreement is not startling, it may be remarked that in only three cases out of twelve is the calculated value more than 0.2 per cent from the observed value, and the maximum difference between calculated and observed values is only about 0.4 per cent (sieve No. 4). Moreover, in this series of tests the weight of the observed values is not so great that we may consider them to be much more reliable than those from the cloth measurements.

The foregoing discussion has been based entirely on the results obtained with the 12 No. 200 standard sieves listed in Table 1, and does not apply to the determinations on the No. 100 sieves.

TABLE 4

Results of Sieving Tests Made by Four Observers on 12 Standard No. 100 Sieves

Sieve	Observers					Average	Maximum variation from average
	A	B	C	D	E		
1	96.28	96.48	96.44	96.64	....	96.46	0.18
2	96.24	96.50	96.58	96.70	....	96.50	.26
3	96.22	96.48	96.44	....	96.86	96.50	.36
4	96.46	96.50	96.42	96.70	....	96.52	.18
5	96.32	96.58	96.48	96.72	....	96.52	.20
6	96.30	96.74	96.50	96.68	....	96.56	.26
7	96.52	96.68	96.52	96.44	96.74	96.58	.14
8	96.48	96.56	96.58	96.74	....	96.59	.15
9	96.54	96.60	96.56	96.66	....	96.59	.07
10	96.54	96.48	96.42	96.90	....	96.59	.31
11	96.64	96.64	96.72	96.64	....	96.66	.06
12	96.59	96.68	96.68	96.96	....	96.73	.23
Average	96.43	96.58	96.53	96.71	....	96.56	.20
Personal equation	+.13	—.02	+.03	—.15	....	....	....

Table 4 is similar to Table 1, containing the results obtained by four observers using 12 "standard" No. 100 sieves. The same method of examination enables us to state that a single determination of fineness on the No. 100 sieve is likely to be at least 0.2 of 1 per cent in error. This value is of course less than the corresponding value for the No. 200 sieve, owing to the smaller quantity of material of this grade, which therefore gives a more definite stopping point in the sieving. Similarly, the range of differences that may be expected between standard sieves is less than that for the No. 200 sieves, being in this case from 96.46 per cent to 96.73 per cent, or 0.27 per cent. The maximum correction of a "standard" No. 100 sieve to the ideal No. 100 sieve therefore appears to be of the order of 0.2 per cent.

A striking agreement is also noted between the "personal equations" as given in Tables 1 and 4, the operators being the same in each case.

TABLE 5

Results of Sieving Tests Made on Nine Standard No. 200 Sieves

Sieve	Observers A	Observers B	Observers C	Average	Maximum variation from average
1	80.26	79.76	....	80.01	0.25
2	80.66	80.48	....	80.57	.09
3	....	81.18	80.68	80.93	.25
4	80.83	81.06	....	80.94	.12
5	....	81.30	80.78	81.04	.26
6	81.36	81.36	....	81.36	.00
7	81.50	81.28	....	81.39	.11
8	81.56	81.80	....	81.68	.12
9	81.70	81.82	....	81.76	.06
Average	81.12	81.12	80.73	81.08	.14

TABLE 6

Results of Sieving Tests Made on Thirteen Rejected No. 200 Sieves

Sieve	Observers			Average	Maximum variation from average
	A	B	C		
1	80.96	80.10	....	80.53	0.43
2	80.78	79.96	81.14	80.63	.67
3	80.80	80.68	....	80.74	.06
4	80.92	80.96	....	80.94	.02
5	81.12	81.06	....	81.09	.03
6	81.36	80.88	....	81.12	.24
7	81.48	81.12	....	81.30	.18
8	81.64	81.12	....	81.38	.26
9	81.18	81.68	....	81.43	.25
10	81.46	81.60	....	81.53	.07
11	82.16	81.42	....	81.79	.37
12	81.84	81.80	....	81.82	.02
13	81.98	82.20	....	82.09	.11
Average	81.36	81.12	81.14	81.26	.21

Tables 5 and 6 contain the results obtained mainly by two observers on 22 No. 200 sieves, 13 of which failed to meet the requirements of standard sieves. These rejected sieves were not of as poor quality as some which have been tested in the laboratory, especially those tested prior to the issuance of the Bureau's sieve specifications.

While in general it may be expected that the rejected sieves will show larger differences from the ideal sieve than the "standard" sieves, this is not necessarily the case. Thus a single bad quarter or half inch strip in the wire cloth may cause the rejection of a sieve, whereas the bad strip may have no appreciable effect on the sieving value. In other words a rejected sieve may frequently have a better sieving value than a standard sieve, and examples of such cases are shown in Tables 5 and 6.

Examination of the tables shows that the observers A and B obtained fairly consistent results in sieving. It is interesting to note that the observed range in sieving values of the standard sieves given in Table 5 is from 80.01 per cent to 81.76 per cent, or 1.75 per cent; that is, nearly twice as great a value as observed in the first lot of sieves.

TABLE 7

Results of Sieving Tests Made on Nine Standard No. 100 Sieves

Sieve	Observers A	Observers B	Observers C	Average	Maximum variation from average
1	95.70	95.76	....	95.73	0.03
2	95.88	96.06	....	95.97	.09
3	95.82	96.28	....	96.05	.23
4	96.00	96.22	....	96.11	.11
5	96.00	96.26	....	96.13	.13
6	95.92 95.90	96.42 96.30	....	96.14	.28
7	96.06	96.30	....	96.18	.12
8	96.06	96.36	....	96.21	.15
9	96.12	96.44	....	96.28	.16
Average	95.95	96.24	....	96.09	.14

TABLE 8

Results of Sieving Tests Made on Thirteen Rejected No. 100 Sieves

Sieve	Observers A	Observers B	Observers C	Average	Maximum variation from average
1	95.60	95.80	96.00	95.80	0.20
2	95.87	95.98	....	95.92	.06
3	95.92	96.04	....	95.98	.06
4	95.95	96.04	....	96.00	.05
5	95.90	96.10	....	96.00	.10
6	96.06	96.12	....	96.09	.03
7	95.95	96.30	....	96.12	.18
8	95.96	96.38	....	96.17	.21
9	96.18	96.18	....	96.18	.00
10	96.02	96.40	....	96.21	.19
11	96.20	96.26	....	96.23	.03
12	96.26 96.42	96.50	....	96.39	.13
13	96.26	96.68	96.26 96.38	96.40	.28
Average	96.04	96.21	96.21	96.11	.12

Tables 7 and 8 give the results obtained mainly by two observers on 22 No. 100 sieves, 13 of which were rejected as "standard" sieves.

Of those which passed the requirements, the lowest sieving value observed is 95.73 per cent and the highest 96.21 per cent, a range of 0.48 per cent. This, again, is nearly twice the corresponding value for the first lot of sieves, but the most striking result is that the highest sieving value in this lot is 0.25 per cent below the lowest sieving value in the first lot.

The personal equations for observers A and B are seen to agree fairly well in Table 4 as compared with Tables 7 and 8, but those given in Table 1 do not agree with those in Tables 5 and 6.

IV. CONCLUSIONS

In reviewing the results of the foregoing tests the following conservative estimates may be given:

1. Employing the present standard method of sieving, the greatest attainable accuracy in single fineness determinations of normal Portland cement on a standard No. 200 sieve, that is, the greatest attainable accuracy in checking uniformity of samples is about 0.2 per cent.

2. "Standard" No. 200 sieves may differ in their sieving values by considerable amounts, such that their corrections to the ideal No. 200 sieve may be at least as great as 0.7 per cent.

3. Errors of at least 0.5 per cent may be looked for in single fineness determinations of normal cements on a standard No. 200 sieve when made in the usual routine manner.

4. Deviations exist in the sieving values of "standard" No. 100 sieves, of a magnitude, roughly, one-half the corresponding values for No. 200 sieves as given above.

5. "Personal equation" appears to be appreciable in hand sieving, as in most laboratory operations, the observed values being as great as 0.3 per cent.

6. The rating of a sieve by some system of demerits assigned from direct measurements appears to be an interesting possibility, and worthy of further study. Should a system be worked

out to give reliable indications say within 0.2 per cent or 0.3 per cent of the observed sieving value of a sieve, it will add greatly to the value of the certificate now furnished with standard sieves.

It seems evident from the foregoing that both sieving tests and the interpretation of measurements on sieves are subject to considerable discrepancies, and the question arises as to whether some other more reliable method of determining fineness can not be made available. The sieve at best is a measure of the *coarseness* of finely ground material rather than the *fineness*, and experiments now in progress at the Bureau of Standards indicate that air separation will offer a more satisfactory means of determining fineness than mechanical sieving.

In conclusion it may be stated that a tolerance of 1 per cent from the specification should be allowed with the No. 200 sieve and 0.5 per cent from the specification with the No. 100 sieve, every care being taken to conduct the test in strict accordance with standard methods. These tolerances should be considered as minimum values since they are based upon the results obtained by careful and experienced observers; therefore it should be emphasized that greater differences are possible in ordinary routine testing.

WASHINGTON, August 1, 1913.

BUREAU CIRCULARS

1. Verification of Standards and Measuring Instruments.
2. Measurements of Length and Area, including Thermal Expansion.
3. Verification of Standards of Mass.
4. Verification of Standards of Capacity.
5. Testing of Clinical Thermometers.
6. Fees for Electric, Magnetic, and Photometric Testing.
7. Pyrometer Testing and Heat Measurements.
8. Testing of Thermometers.
9. Testing of Glass Volumetric Apparatus.
10. Legal Weights (in pounds) per Bushel of Various Commodities.
11. The Standardization of Bomb Calorimeters.
12. Verification of Polariscopic Apparatus.
13. Standard Specifications for the Purchase of Incandescent Electric Lamps.
14. Samples of Analyzed Irons and Steels.—Methods of Analysis.
15. The International Unit of Light.
16. The Testing of Hydrometers.
17. Magnetic Testing.
18. Standard Sheet Metal Gage.
19. Standard Density and Volumetric Tables.
20. Testing of Electrical Measuring Instruments.
21. Precision Measurements of Resistance and Electromotive Force.
22. Standard Specifications for Transformers, Oil-immersed, Self-cooled 60-cycle, 2200 volts.
23. Standardization of Electrical Practice in Mines.
24. Publications of the Bureau of Standards.
25. Standard Analyzed Samples.—General Information.
26. Analyzed Iron and Manganese Ores.—Methods of Analysis.
27. The Testing and Properties of Optical Instruments.
28. The Determination of the Optical Properties of Materials.
29. Announcement of a Change in the Value of the International Volt.
30. Lime: Its Properties and Uses.
31. Copper Wire Tables.
32. State and Municipal Regulations for the Quality, Distribution, and Testing of Illuminating Gas.
33. United States Government Specifications for Portland Cement.
34. The Relation of the Horsepower to the Kilowatt.
35. Melting Points of Chemical Elements.
36. The Testing and Properties of Electric Condensers.
37. Electric Wire and Cable Terminology.
38. The Testing of Mechanical Rubber Goods.
39. Specifications for and Measurement of Standard Sieves.
40. Sodium Oxalate as A Standard in Volumetric Analysis.
41. Testing and Properties of Textile Materials.
42. Metallographic Testing.
43. The Metric Carat.
44. Polarimetry.
45. The Testing of Materials.
46. The Testing of Barometers.